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ORIGINAL PAPER

The pattern, peculiarities, and management challenges of spina bifida in a teaching hospital in Southwest Nigeria

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Abstract
Purpose Spina bifida is a common congenital anomaly of the nervous system. It is frequently associated with significant morbidity and sometimes mortality in affected children. In this paper, we review the clinico-epidemiological pattern, peculiarities, and therapeutic challenges of this condition in our practice setting.
Methods This is a retrospective study of all cases of spina bifida managed from July 2000 to March 2016 at a tertiary health facility located in the southwest region of Nigeria. Relevant information was retrieved from the medical records. The data was collected using a pro forma and analyzed with SPSS version 22.
Results Data from 148 patients was reviewed and analyzed. There were 78 males and 70 females. Only 5.8% of these children were delivered at the health institution. A fifth (20%) of the patients were first born of their mothers. The mean maternal age was 29 years. Few (10.1%) mothers use folate medication prior to conception and only 58% of the mothers use folate during antenatal care. Mean duration of pregnancy was 38 weeks. The most common anatomical site was lumbosacral region (74.3%) while the most common pathology was myelomeningocele 80.4%. Mean age at surgery was 88.68 h. Mean duration of surgery was 92.8 min. Mean follow-up duration was 46.8 weeks. As many as 59% of the patients had some neurologic improvement noticed during follow-up clinic visits.
Conclusion Spina bifida occurs frequently in our environment. Low socio-economic status and poor antenatal clinic visits contributes significantly to its occurrence.

Keywords Spinal bifida · Pattern · Peculiarities · Challenges

Introduction

Spina bifida is a type of neural tube defect resulting from incomplete closure of the neural tube during embryonic development. It is one of the most common congenital anomaly of the nervous system seen in our practice and represents a significant source of childhood morbidity and mortality worldwide (Figs. 1, 2, 3, and 4). It is frequently associated with neurological deficits below the level of the lesion, long-term physical and cognitive disabilities, and developmental delays [11].

Spina dysraphism had existed in Africa since antiquity [9, 10, 15]. Interestingly, the first reported case in Nigeria was in the 1920s by a description of a neonate with spina bifida in the national yearly medical report [31]. However, the scenario in Nigeria is not clear because of the paucity of literature on spinal dysraphism in the country [18]. The incidence of spina bifida is unknown in many parts of Nigeria, except the 22.5% incidence in western Nigeria reported by Adeyemo and colleagues and 7/1000 deliveries reported by Airede et al., in the middle belt of Nigeria [2, 3]. In a study by

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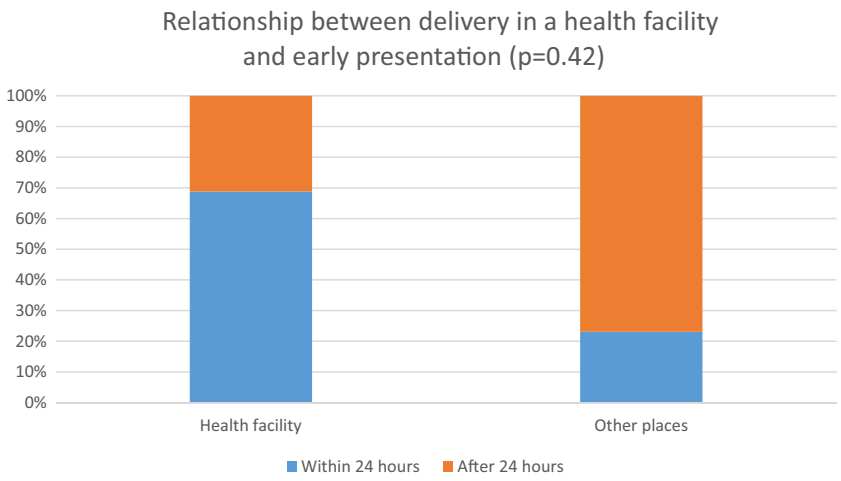

Fig. 1 Relationship between delivery in a health facility and early presentation ($p = 0.42$)

Singh et al. [25], carried out in the northwest region of Nigeria, 72 congenital anomalies were noted in 10,163 deliveries, and central nervous system (CNS) anomalies had the highest prevalence of 34.7% of which spina bifida was the most common CNS anomaly followed by hydrocephalus 28%.

In this paper, we looked at the pattern and peculiarities of the spina bifida cases we have managed in our unit and also highlight some challenges encountered in the management of these patients.

Patients and methods

We retrospectively reviewed all the cases of spina dysraphism seen and managed in the neurosurgery unit of Department of Surgery, Obafemi Awolowo University Teaching Hospitals Complex from July 2000 to March 2016. The unit is a neurosurgical center in this teaching hospital located in Southwest Nigeria, and until recently the only neurosurgical center in the state and five neighboring states serves a population of about eight million. The patients comprised all children with spinal mass lesions noticed at birth. The hospital clinical notes and the operation notes were reviewed after ethical clearance was obtained from the institution's ethical committee. The information retrieved from the hospital records were entered into a pro forma form designed for the study.

Data obtained from the records included the site and size of midline spinal swellings, spinal level of involvement, presence of neurologic deficits, associated complications, head circumference, and presence of other congenital deformities. We also documented maternal history including maternal age and occupation and estimated gestational age at booking for antenatal care, duration of pregnancy, pregnancy history, and use of folate in the antenatal and pre-pregnancy periods. Other information collected were whether surgery was done or not, duration of surgery, estimated blood loss, need for simultaneous shunting or shunting at a later date, duration of admission and follow-up, and the outcome of surgery. We analyzed the patients that were operated and whose records were complete using SPSS version 22 and the results are presented in this presentation.

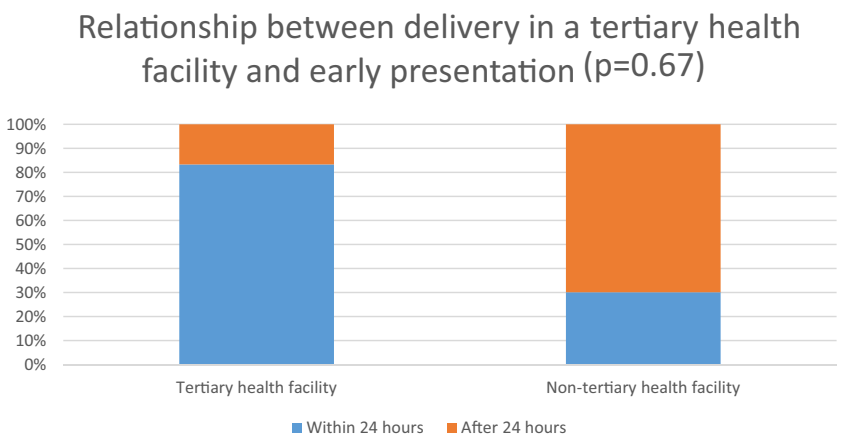

Fig. 2 Relationship between delivery in a tertiary health facility and early presentation ($p = 0.67$)

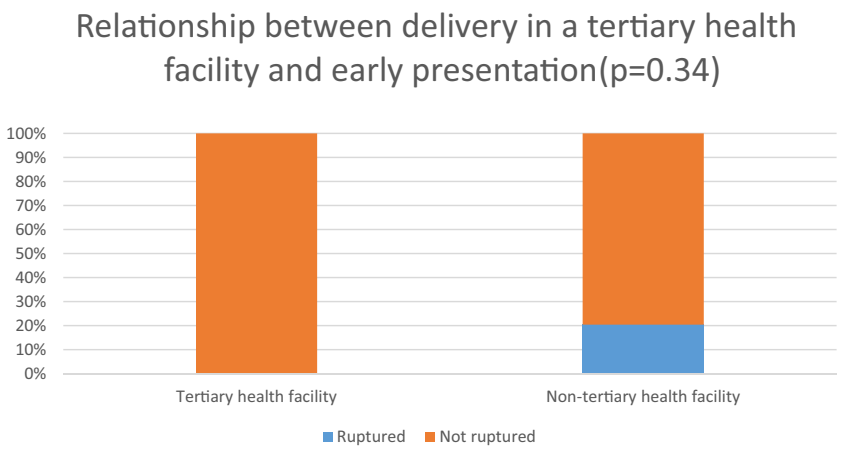

Fig. 3 Relationship between delivery in a tertiary health facility and early presentation ($p = 0.34$)

Results

Our record showed that 252 patients with spina dysraphism were seen by our unit during the period under review. These patients were first seen at the surgical outpatient clinic, the children emergency ward, and the neonatal and the postnatal wards. However, only 148 (58.7%) of these patients had complete data for analysis. The remaining 104 patients were those who were either discharged against medical advice (DAMA) or died before surgery could be carried out usually due to financial constraints, multiple congenital anomalies, or severe sepsis in some cases. Majority of those that were discharged against medical advice do so after parental counseling about the pathology, treatment plans, and possible outcomes even after surgical intervention. There were three older patients (ages 5, 6, and 10 years) among those not operated or presented in this communication because we could not guarantee complete neurological recovery following surgery, in particular full restoration of sphincter functions.

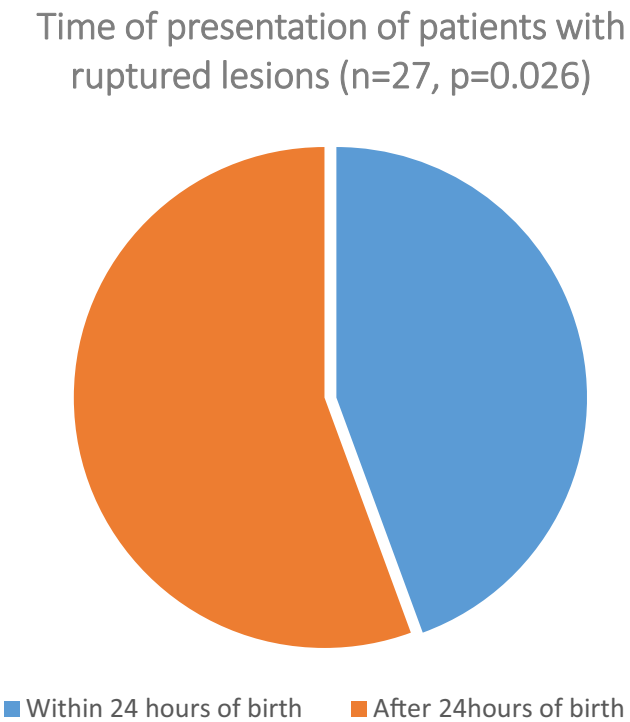

Fig. 4 Time of presentation of patients with ruptured lesions ($n = 27$, $p = 0.026$)

Among the 148 patients analyzed and presented, there were 78 males and 70 females with a M/F of 1.1:1. The mean age of the patient was 40.3 days (range 1 day to 48 months). Ninety-six (64.6%) patients presented within a week after birth while 18 (12.2%) presented after 3 months of life. Seventy-three (49.3%) of the children were either first or second born of the family while 48 (32.5%) were of higher rank order in the family (Table 1). The mean duration of pregnancy was 38.9 weeks (range 32 to 42 weeks) and 94.4% of the patients were delivered at full term. About 95% of the mothers were married with mean maternal and paternal age of 29 and 36.5 years, respectively. The mean estimated gestational age at booking was 19.73 weeks while majority of the women (66%) booked in the second trimester (Table 2). About half (47.5%) of the mothers were petty traders while 18.9% were artisans. Only 24.3% mothers had tertiary education while 59.5% had secondary school education. Also, about a third (30%) of the mothers used pre-conception folate medications; however, 82.4% of them used antenatal folate medications only when the pregnancy was well advanced.

There were no major ailments in the mothers during their pregnancies that required hospitalization but 9.2% of the women had febrile illness during pregnancy. This was treated with antimalarials and antibiotics in three mothers in whom urinary tract infection was suspected (Table 3). Only 5.8% of the patients were delivered in our center while the others were delivered in private and mission hospitals or maternity or spiritual homes from where they were referred. The most commonly affected anatomic site was the lumbosacral region

Table 1 Basic epidemiologic data of the patients

Patient's data	Number of cases	Percentage (%)
Age groups at presentation		
< 24 h	40	27.2
> 24 h to 1 week	56	37.4
> 1 week to 1 month	24	16.3
> 1 to 3 months	10	6.8
> 3 to 6 months	10	6.8
> 6 months to 1 year	7	4.7
> 1 to 5 years	1	0.7
Gender		
Males	78	52.3
Females	70	47.7
Position of child in family		
1st born	34	22.8
2nd born	39	26.5
3rd born	27	18.4
4th born	33	22.1
5th born	11	7.4
6th born	4	2.9
Place of birth		
Within OAUTHC	8	5.8
Other public hospitals	46	30.8
Private hospital houses	79	53.4
Home	15	10

(80.3%) followed by the lumbar region (11.7%). The main pathological type was myelomeningocele (86.2%) followed by meningocele (11.6%). The occulta type was only 0.8% in the series (Table 4). Complications associated with the lesion included rupture (23.5%) and sepsis (25.8%). The most frequent sensory level found following evaluation was the fifth lumbar spinal cord segment L5 (26.7%) followed by the third lumbar cord segment L3 (23.3%) while the two most

Table 2 Mean, median, and modal distribution of the patients

	Measures		
Variables	Mean	Median	Mode
Patient's age (days)	40.29	3	1
Maternal age (years)	29.01	29.00	25
Paternal age (years)	36.54	35.00	40
EGA at booking (weeks)	19.73	17.00	17.00
Duration of pregnancy (weeks)	38.92	39.00	39
OFC (cm)	36.22	35.00	35.00
Size of lesion (cm)	Length 5.9 Breadth 5.26 Height 4.01	Length 6.0 Breadth 5.0 Height 3.0	Length 6.0 Breadth 6.0 Height 3.0
Duration of surgery (min)	92.80	75	120
Estimated blood loss (ml)	14.63	0.00	0
Age at surgery (h)	88.68	20.00	14
Follow-up (weeks)	46.85	4.00	2.00

Table 3 Maternal epidemiologic data

Variables	Number	Percentage (%)
Marital status		
Single	7	4.4
Married	141	95.6
Mother's occupation		
Artisans	28	18.9
Civil servants	7	4.9
Clerks	3	2.5
Farmers	7	4.9
House wives	12	8.2
Not working	3	1.6
Nurses	3	1.6
Other professionals	3	1.6
Students	6	4.1
Teachers	6	4.1
Trader	70	47.5
Mother's education level		
Primary school	24	16.2
Secondary school	88	59.5
Tertiary education	36	24.3
Duration of pregnancy		
Preterm	7	4.7
Early term	6	3.8
Full term	128	86.8
Late term	6	3.8
Post-term	1	0.9
Trimester at booking		
1st	28	19.4
2nd	98	66
3rd	22	14.6
Pre-pregnancy folate use		
Did not take folate	104	70
Took folate	44	30
Antenatal intake of folate		
Did not use folate	26	17.6
Took folate	122	82.4
Illness during pregnancy		
Cough	1	0.8
Febrile illness	14	9.2
Jaundice	3	1.7
Malaria	4	2.5
None	126	85.8
Maternal intake of antiepileptics	0	0

Table 4 Distribution of the pathology

Variables	Number	Percentage (%)
Site		
Lumbar	17	11.7
Lumbosacral	119	80.3
Sacral	10	6.6
Thoracolumbar	2	1.5
Lesion		
Meningocele	18	11.6
Myelomeningocele	127	86.2
Myelocele	2	1.4
Spina bifida occulta	1	0.8
Associated complications		
None	70	47.2
Rupture	28	19.0
Rupture and sepsis	5	3.6
Sepsis	31	20.5
Ulceration	12	7.9
Ulceration and sepsis	1	0.9
Ulceration, rupture, and sepsis	1	0.9

frequently involved motor levels were S1 (28.6%) and L3 (23.8%), respectively. Ninety-seven percent (125/129) of the myelomeningocele and myelocele had patulous anus and were incontinent of urine. However, following surgery and untethering of the nerves, some improved but many still had residual weak anal sphincters (90/129, 70%) and weak urethral sphincters (39/129, 30%).

Congenital malformations associated with these conditions are depicted in Table 5, the most common being congenital talipes equinovarus (53.4%). Hydrocephalus was also frequently related and ranked second (46.6%). The mean age at surgery was 88.68 h while mean duration of surgery was 92.80 min with mean estimated blood loss of about 14.63 ml (Table 2). Only two cases had simultaneous shunting for hydrocephalus and excision and repair of the spina bifida. Estimated blood loss was negligible in cases operated. Most procedures were done on elective basis (86.4%) while the rest, especially the ruptured cases, were done as emergencies. Some cases were done as day-case procedures when the patients were fit and as such were not admitted. Majority of the admitted cases stayed for 2–4 days post-operatively. However, the cases with complications stayed longer (6–13 days). The complications noted in 31.1% of the patients post-operatively are shown in Table 6. The mean follow-up duration was 46.85 weeks with the largest follow-up duration being more than 1 week to 6 months.

The outcome of management is as shown with more than 50% patients achieving some neurologic improvement observed during follow-up clinic visits. Further analysis showed that post-operative complications were equally common to both ruptured and intact lesions (Table 7). Figure 1 revealed that babies delivered in a health facility are likely to present within 24 h when compared to those delivered in other places such as the home. Figure 2 further

Table 5 Associated congenital malformations

Malformation	Number	Percentage (%)
Hydrocephalus	69	46.6
Microcephaly	1	1.2
Low-set ear	1	1.2
Chest wall deformity	1	1.2
Hydrocele	1	1.2
Retractile testes	1	1.2
Congenital hip dysplasia	3	3.3
Arthrogryposis	1	1.2
Genu recurvatum	1	1.2
Congenital talipes equinovarus	46	53.4
Talipes calcaneovarus	1	1.2

Table 6 Treatment

Variables	Number	Percentage (%)
Estimated blood loss		
Negligible	96	65.2
5	2	1.2
20	9	6.0
35	9	6.0
45	5	3.6
60	11	7.2
110	7	4.8
180	9	6.0
Type of surgery		
Elective	128	86.4
Emergency	20	13.6
Complications of surgery		
No complications	103	69.9
Anemia	2	1.1
Aspiration pneumonitis	2	1.1
CSF leak	11	8.4
Respiratory difficulty	2	1.1
Hydrocephalus	5	3.4
Meningitis	2	1.1
Recurrence	2	1.1
Sepsis	9	6.8
Wound dehiscence	5	3.4
Wound infection	5	3.4

Table 7 Post-operative complications as related to rupture of the lesion at presentation

	Wound infection ($p = 1.00$)		Wound dehiscence ($p = 1.00$)		Post-op sepsis ($p = 0.63$)		Post-op meningitis ($p = 0.33$)		CSF leak ($p = 1.00$)	
Rupture at presentation	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)
Ruptured	0 (0.0)	27 (100.0)	0 (0.0)	27 (100.0)	2 (7.4)	25 (92.6)	1 (3.7)	26 (96.3)	0 (0.0)	27 (100.0)
Not ruptured	4 (3.3)	117 (96.7)	3 (2.5)	118 (97.5)	6 (5.0)	115 (95.5)	1 (0.8)	120 (99.2)	3 (2.5)	118 (97.5)

shows that more patients born in tertiary health facilities presented earlier than those born in other health institutions. While Fig. 3 demonstrates that no ruptured case was seen in those delivered at tertiary health institutions, Fig. 4 shows that more than half of the ruptured cases still presented after 24 h post-delivery. Most of the post-operative complications were observed in patients that came late, i.e., after 24 h (Table 8). Table 9 shows that with delayed presentation, more lesions were complicated. Figures 5, 6, 7, and 8 are illustrations of a few of our patients managed over the period under review.

Discussion

This study demonstrates that spina dysraphism is still common in our environment and the incidence seems not to be abating. Despite the fact that these lesions are noticed and diagnosed at birth, many patients still present late. This is not unusual in our practice setting as late presentations to health facilities are common. Many factors are responsible for late presentation such as poverty, living far from health care institutions, visitation to traditional healers, and sometimes delayed referral from other medical facilities. The reasons for delayed presentation in cases of spina bifida and other congenital anomalies are well discussed in a previous paper [13]. Many patients who presented very late to our facility eventually seek medical help because of persistent rectal and urethral sphincteric dysfunctions when the children are about to or have started schooling and the social embarrassment attached to it.

There was a slight male preponderance in this study. Gender differences exist with spina bifida and sometimes conflicting. Many literatures observed female predominance [7, 17] which appears to be influenced by the presence of additional birth defects, geographical areas, and other factors such as the differences between the sexes in embryonic developments' susceptibility to teratogenic insult and spontaneous abortion rates [21]. Some investigators however reported male predominance in their works [4, 19]. Most of the babies in this study were delivered outside our hospital and subsequently referred to us. This is similar to the findings of Audu et al. [6], where 88.5% of the cases of neural tube defect were born outside tertiary health institutions before being referred for expert care. Our country with a population of about 170 million has only 40–45 neurosurgeons working mainly in tertiary health institutions which are not evenly spread across the nation.

All the mothers in our series have some form of formal education at least up to some level. There was no level of illiteracy found unlike in the study by Abdelmoneim et al. [1], where a 13.2% level of illiteracy was noted. This shows that irrespective of educational level or social status, spina bifida can still occur. It is expected that the more educated mothers would be aware of the benefits of folic acid use prior to conception to reduce the risk of spinal bifida. However, we did not notice the impact of education on the occurrence of these lesions. Many mothers were afraid to get pregnant again after having a child with spina bifida but of those that did not stop child bearing, none had a repeat case of spina bifida. As many as 70% of the mothers in this study did not take folate in any form before pregnancy and most of them commenced the antenatal clinic either late in the second trimester or in the third

Table 8 Post-operative complications as related to time of presentation

	Wound infection ($p = 0.58$)		Wound dehiscence ($p = 0.56$)		Post-op sepsis ($p = 1.00$)		Post-op meningitis ($p = 1.00$)		CSF leak ($p = 0.56$)	
Presentation	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)
≤ 24 h of birth	0 (0.0)	40 (100.0)	0 (0.0)	40 (100.0)	2 (5.0)	38 (95.0)	0 (0.0)	40 (100.0)	0 (0.0)	40 (100.0)
> 24 h of birth	4 (3.7)	103 (96.3)	3 (2.8)	104 (97.2)	6 (5.6)	101 (94.4)	2 (1.9)	105 (98.1)	3 (2.8)	104 (97.2)

Table 9 Complications of the lesion at presentation

Presentation	Rupture (p = 0.026)		Sepsis (p = 0.38)		Ulceration (p = 0.35)	
	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)
≤ 24 h of birth	12 (30.0)	28 (70.0)	6 (15.0)	34 (85.0)	4 (10.0)	36 (90.0)
> 24 h of birth	15 (14.0)	92 (86.0)	23 (21.5)	84 (78.5)	6 (5.6)	101 (94.4)

trimester when the neural tube formation would normally have been completed, and folic acid would have produced its desired effect. Among those that attended antenatal care and had ultrasound scanning done, only five cases were suspected prior to delivery. In the study by Singh et al., diagnosis of most of the anomalies (69.4%) was made after delivery [25]. This makes purchase of high-resolution ultrasound machines and trained and experienced sonologist indispensable. The critical period during which the neural tube closes is between the 21st and 26th day of gestation [5]. This understanding forms the basis for the current folic acid supplementation policies in the developed countries [27]. For instance, in Britain, a woman who plans to become pregnant is placed on folate supplementation of 4 mg daily 1 month before conception to the 12th week of pregnancy [28]. Also in the USA, the recommendation is that all women of child bearing age who are capable of becoming pregnant should ingest 0.4 mg of folic acid daily in order to reduce the risk of the fetus developing spinal dysraphism [23]. Food fortification with folate may reduce spina bifida occurrence especially in our environment where up to 42% of mothers do not attend antenatal care and those that attend register too late [29].

Other potential risk factors for spina bifida, though weak and not consistently replicated, have been identified. These include maternal use of antiepileptics like valproic acid or carbamazepine, febrile illness, and use of unprescribed medications during pregnancy [1]. Malaria fever is common and endemic in our environment and this should be prevented and/or eradicated as soon as diagnosed since previous studies identified fever and hyperthermia in pregnancy as risk factors for development of neural tube defects. History of maternal febrile illness during pregnancy was present in 75% of the mothers in the series by Singh et al [25]. They also found 50% of febrile cases in pregnancy were associated with central nervous system anomalies [25].

Globally and in this study, myelomeningocele is the most common type of spinal dysraphism except unusually in Zaria, Nigeria, where meningocele appears to be more common than myelomeningocele [3, 26]. There seems to be contrasting views on the common site affected in spina bifida [14]. For instance, Champbell and others reported that approximately 80% of all lesions in infants with spina bifida occurred in the lumbar region [8]. Some studies found the lumbosacral region to be the most common site while a study done in Zambia showed the sacral region to be the most common site [12, 16, 26]. However, our findings support the lumbosacral region as the most common site of involvement. A significant number of our patients at presentation had rupture of the spina bifida cysts while some had consequent infections, meningitis or septicemia, which are commonly associated with high morbidity and mortality.

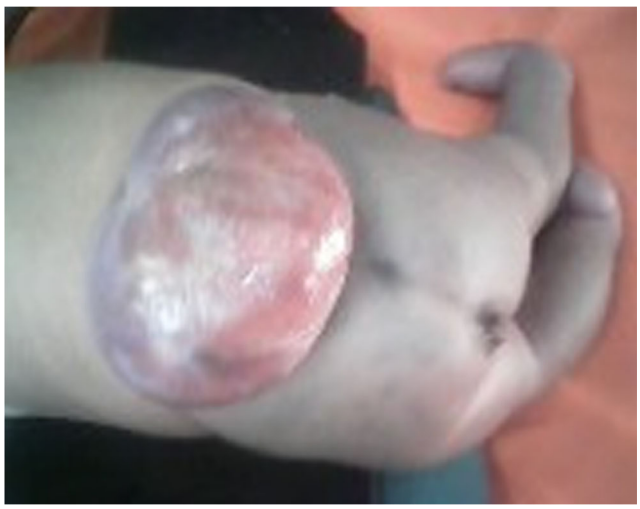

Fig. 5 A baby with huge spina bifida associated with bilateral limb weakness and ankle deformities

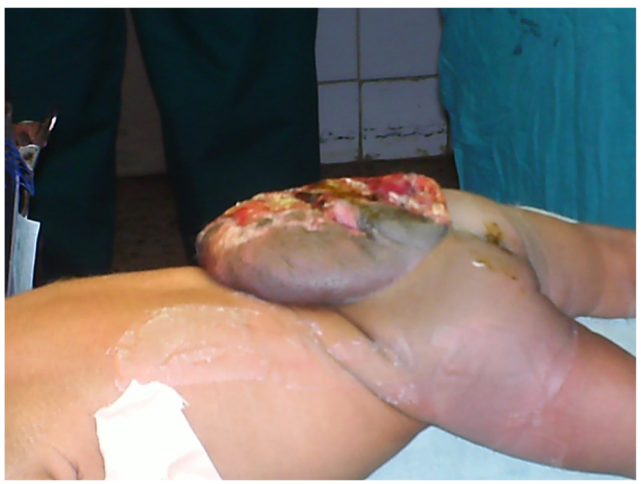

Fig. 6 Rupture of a lumbosacral myelomeningocele

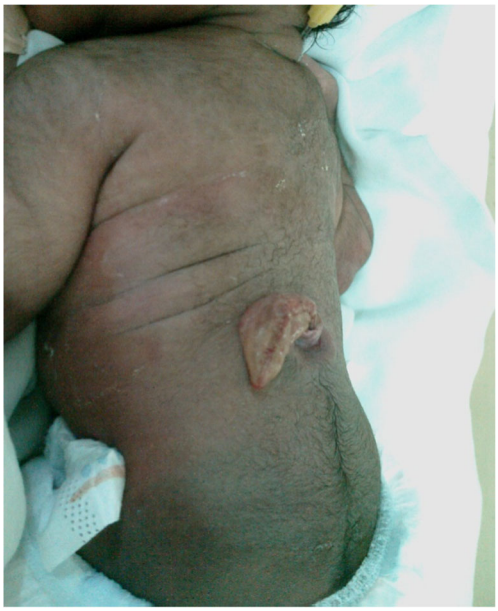

Fig. 7 Thoracolumbar spina bifida showing rupture of a meningocele cyst

A lot of other congenital anomalies are frequently associated with spina dysraphism and some patients have multiple congenital birth defects. Like in many studies, we also noted hydrocephalus and ankle deformities to be the most common associated anomalies. At times, some of these patients presents with pressure sores and wounds on the lower limbs due to inadequate parental care [30]. Patients with spina bifida have 80 to 85% chance of developing hydrocephalus [24]. We however noted only 46.6% in our study. This may be due to the fact that not all the cases are severe forms of spina bifida such as myelomeningocele or myelocele. The other possibility is that many of the patients were lost to follow-up. More than half of our patients had associated neurologic deficits, which are mainly weakness or paralysis of the lower limbs with inability to walk and sphincteric dysfunction. After assessment of the patients and discussion with their parents regarding the possible neurological outcomes (especially that the child may not be able to walk or control his/her sphincters even after surgery), many parents do not see the need for surgery and then either request for discharge or fail to come back to the clinic.

We were able to achieve primary closure for all the cases operated with no need for plastic surgical intervention despite the fact that many of these patients were done as day-case procedures [22]. This is in contrast to the study conducted by Nidal et al., in which all 93 cases of spina bifida aperta were operated and had wounds closed primarily but with assistance from plastic surgeons to raise flaps for closure when defects were bigger than 7.5 cm in dimension for some cases [20]. Complications of surgery observed in our series are not unusual as some of these have been reported by other workers. Although some reported neurologic deterioration after repair, our study did not reveal any.

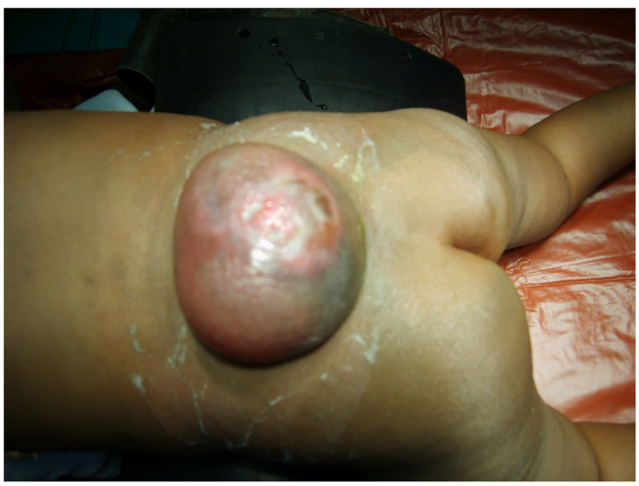

Fig. 8 A lumbosacral myelomeningocele with a healed placode

Conclusion

The high occurrence of spina dysraphism in our environment underscores the need to promote global and effective preventive measures aimed at these lesions. Such measures must include mass public health education on the value of good nutrition, balanced diet, and, in women of child bearing age, pre-conception folic acid intake and early antenatal care. Government and community intervention in the management and care of these patients cannot be overemphasized.

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Compliance with ethical standards

Conflict of interest The authors confirm that there are no disclosures, no conflicts of interest, and no financial support.

References

1. Abdelmoneim EM, Kheir I, Wala MH (2015) Neural tube defects; clinical patterns, associated risk factors and maternal awareness in Khartoum state, Sudan. J Med Med Res 3:1–6
2. Adeyemo AA, Gbadegesin RA, Omotade OO (1997) Major congenital malformations among neonatal referrals to a Nigerian university hospital. East Afr Med J 74:699–701
3. Airede KI (1992) Neural tube defects in the middle belt of Nigeria. J Trop Pediatr 38:27–30
4. Alatise OI, Adeolu AA, Komolafe EO, Adejuyigbe O, Sowande OA (2006) Pattern and factors affecting management outcome of spina bifida cystica in Ile-Ife, Nigeria. Paediatr Neurosurg 42:277–283

5. Asindi A, Al-Shehri A (2001) Neural tube defects in the Asir region of Saudi Arabia. Ann Saudi Med 21:26–29
6. Audu LI, Shehu BB, Thom-Manuel IJ, Mairami AB (2004) Open neural tube defects at the national hospital Abuja: an analysis of clinical pattern and neonatal outcome. Niger J Paediatr 31:131–136
7. Buccimazza SS, Molteno CD, Dunne TT et al (1994) Prevalence of neural tube defects in Cape Town. Teratology 50:194–199
8. Champbell KS, Vander L, Palisano R (2006) Physical therapy for children. W.B. Saunders Company, Philadelphia
9. Charon P (2005) Tératologie du tube neural: histoire et paléopathologie. Antropo 10:83–101
10. Ferembach D (1959) [Paléontologie humaine.] Les restes humains épipaléolithiques de la grotte de Taforalt (Maroc oriental). [Note de Mlle Denise Ferembach présentée par M. Jean Piveteau.] Comptes rendus hebdomadaires des séances de l'Académie des sciences. 248:3465–3467
11. Hetherington R, Dennis M, Barnes M, Drake J, Gentili F (2006) Functional outcome in young adults with spina bifida and hydrocephalus. Childs Nerv Syst 22:117–124
12. Idowu OE, Apemiye RA (2008) Outcome of myelomeningocoele repair in sub-saharan Africa: the Nigerian experience. Acta Neurochir 150:911
13. Komolafe EO, Komolafe MA, Adeolu AA (2008) Factors implicated for late presentations of gross congenital anomaly of the nervous system in a developing nation. Br J Neurosurg 22(6):764–768
14. Komolafe EO, Shokunbi MT, Malomo AO (2004) Thoracic myelocystomeningocele in a neurologically intact infant—a case report. West Afr J Med 23(1):79–80
15. Kuttner RE (1978) Prehistoric spina bifida occulta. J Am Med Assoc 240(24):2631
16. Lungu MM (2001) Epidemiological characteristics of patients with myelomeningocele presenting to university teaching hospital—Lusaka. Master's Degree Thesis, University of Zambia
17. Mitchell LE, Adzick NS, Melchionne J, Pasquariello PS, Sutton LN, Whitehead AS (2004) Spina bifida. Lancet 364:1885–1895
18. Mulholland CB, Calgua E, Contreras F, Espinoza D, Gonzalez A, Gonzalez JB, Komolafe E, Lazareff J, Mancilla JLS, Mannucci G, Nan B, Parra H, Portillo S (2011) The International Tethered Cord Partnership: beginnings, process, and status. Surg Neurol Int 2:38. https://doi.org/10.4103/21527806.78239
19. Mweshi MM, Amosun SL, Shilalukey-Ngoma MP, Munalula-Nkandu E (2015) Ethnic pattern of origin of children with spina bifida managed at the University Teaching Hospital and Beit Cure Hospital, Lusaka, Zambia 2001-2010. Sci J Public Health 3:852–856
20. Nidal HK, Abdullah TA (2002) Neural tube defects in newborns. Neurosciences 7:112–114
21. Oduro H (2008) Enrichment of foods with folate: its impact on the prevalence of genetic associated diseases in African countries as compared to western countries. http://departments.agri.huji.ac.il/external
22. Owojuyigbe AM, Komolafe EO, Adenekan AT, Dada MA, Onyia CU, Ogunbameru IO, Owagbemi OF, Talabi AO, Faponle FA (2016) Paediatric day-case neurosurgery in a resource challenged setting: pattern and practice. Afr J Paediatr Surg 13(2):7681
23. Recommendation of the use of folic acid to reduce the number of cases of spina bifida and other neural tube defects (1992) MMWR 4:1
24. Rintoul NE, Sutton LN, Hubbard AM, Cohen B, Melchionni J, Pasquariello PS, Adzick NSA (2002) New look at myelomeningoceles: functional level, vertebral level, shunting, and the implications for fetal intervention. Pediatrics 109:409–413
25. Singh S, Chukwunyere DN, Omembelede J, Onankpa B (2015) Foetal congenital anomalies: an experience from a tertiary health institution in northwest Nigeria (20112013). Niger Postgrad Med J 22(3):1748
26. Shehu BB, Ameh EA, Ismail NJ (2000) Spina bifida cystic: selective management in Zaria, Nigeria. Ann Trop Paediatr 20:239–242
27. Shin M, Kucik JE, Siffel C, Lu C, Shaw GM, Canfield MA, Correa A (2012) Improved survival among children with spina bifida in the United States. J Pediatr 161:1132–1137
28. The MRC Vitamin Study Research Group (1991) Prevention of neural tube defect: results of the Medical Research Council Vitamin Study. Lancet 338:131–137
29. Uba AF, Isamade ES, Chirdan LB, Edino ST, Ogbe ME, Igun GO (2004) Epidemiology of neural tube defects in North Central Nigeria. Afr J Paediatr Surg 1:16–19
30. Van't Veer T, Meester H, Poenaru D, Kogei A, Augenstein K, Bransford R (2008) Quality of life for families with spina bifida in Kenya. Trop Dr 38:160–162
31. Wilson G (1924) Spina bifida with meningocele and hernia cerebri frontal. Annual medical & sanitary report, Nigeria. Appendix 4:67–68